FAA National Software Conference, June 2001
WAAS Experience

DO-178B
WAAS Experience

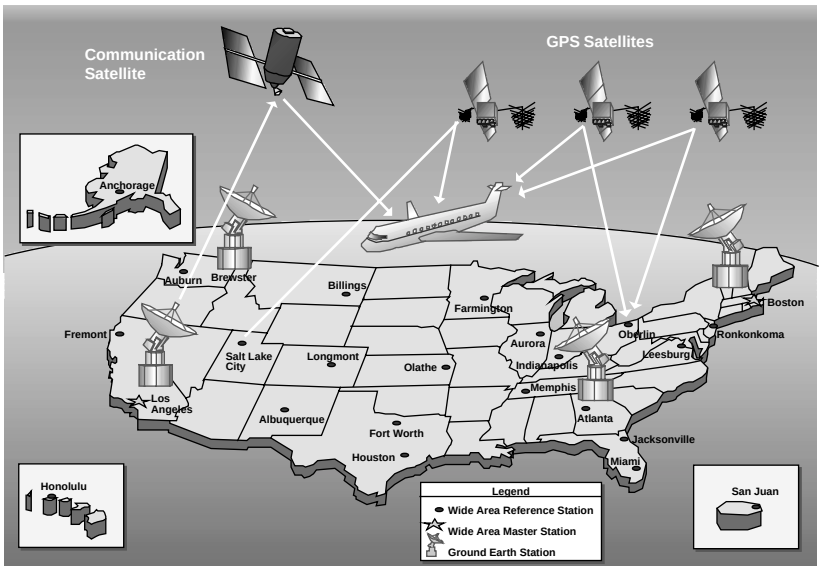
Presented by:
John Besnard

What is WAAS?

- A ground-based, large-scale software, COTS intensive, firmware and complex logic controlled navigation aid system.
  - 15 major COTS components
  - 470K lines of delivered code
  - Two different types of real-time platforms
  - Large dual terrestrial communications network
  - Geo-synchronous satellite uplinks

FAA National Software Conference, June 2001
WAAS Experience

WAAS Overview



WAAS Today

- All sites have been fielded
- WAAS is operating 24/7
- Corrects GPS signals to 1 meter horizontally and 1.5 meters vertically 95% of the time
- Many users already count on WAAS
  - Precision farming
  - Marine navigation
  - Crop dusting

WAAS Today

- The Garmin GPSMAP 76 (left) is designed to provide precise GPS positioning using correction data obtained from the Wide Area Augmentation System. This unit features a built-in quad helix antenna for superior reception and can provide position accuracy to less than three meters when receiving WAAS corrections.

WAAS Today

The new Raynav 300 GPS plotter is aesthetically designed to co-ordinate and interface with Raymarine's on board system equipment. This clever unit provides positioning accuracy and reliability with classic Raymarine ease of use. WAAS signals give position fixes accurate to 2.5m within a coverage area including the complete United States from longitude 165 degrees East to 45 degrees West

WAAS Today

Military&Aerospace ELECTRONICS®

- 18 April, 2001 - Leaders of UPS Aviation Technologies in Salem, Oregon, say they plan to seek certification this summer for a first-of-its-kind GPS navigation receiver that will use existing signals from the FAA's Wide Area Augmentation System (WAAS) to enable aircraft precision instrument approaches.
- First installations would be in the data processing unit of the UPS Aviation Automatic Dependent Surveillance-Broadcast (ADS-B) product line for parent cargo carrier UPS' fleet.

Development Environment

- The "C" programming language was mandated by the contract
- "Maximum use of COTS" was mandated by the contract
- DO-178B invoked by contract
- Extensive simulation capability was required
- Lab development systems are now linked to "real world" GPS signals

WAAS Software Status

- Four software configuration items (CSCI) were developed
  - ALL CSCIs have finished FQT
- All verification tools have completed qualification
- WAAS signal has been broadcast essentially 24/7 since January 2000
- New integrity monitors are currently in development, as is documentation to support certification by the FAA

COTS Status

- Two different real-time operating systems are being used
  - AIX for RS6000 processors
  - VRTXsa for PowerPC processors
- The PowerPC is being replaced
  - A change to the Operating System is underway
  - Thus invoking section 12.1.3 of DO-178B

DO-178B Issues

- We were true “First Timers” when we started
- The contract required us to follow both DOD-STD-2167A (via FAA-STD-026) and DO-178B
- The language of DO-178B was new to us
  - “Derived” requirements do **NOT** trace in DO-178B-speak
  - “Independence” confused us
  - “Qualification” vs. “Verification” vs. “Test” didn’t make sense
  - We had a different historical meaning for “Robustness testing”
- Software level B requirements tracing went lower than our standard process required

DO-178B Issues (continued)

- WAAS was the first ground based system to require DO-178B
  - There were no models to follow
  - DO-178 has “Airborne” in its title
  - There is no “certification” authority
- The compliance audit process was very different than what we expected
  - Our first audit was eye-opening!
- Data volume and the importance of record keeping became more and more obvious

DO-178B Issues (continued)

- "Data & Control Coupling" guidance was skimpy
- SC-190 guidance was not available when we began
- DO-178B doesn't provide a lot of help when dealing with COTS

COTS Issues

- Most suppliers are not interested in supporting DO-178B
  - Most haven't heard of it, nor do they want to
- Some of the objectives for software level D, when applied to COTS, required "creative" interpretations
  - E.g., Table A-2, objective 6 "Source Code is developed" refers to section 5.3.1a which requires, "traceable, consistent" code. With COTS, the methods used to develop the code are not often available, so we stated, "Since the object code executes correctly, the source code must have been developed properly."
  - Note that FAA Notice 8110.82 solved this problem
- Configuration Management and Quality Assurance of necessity fall on us, rather than the supplier

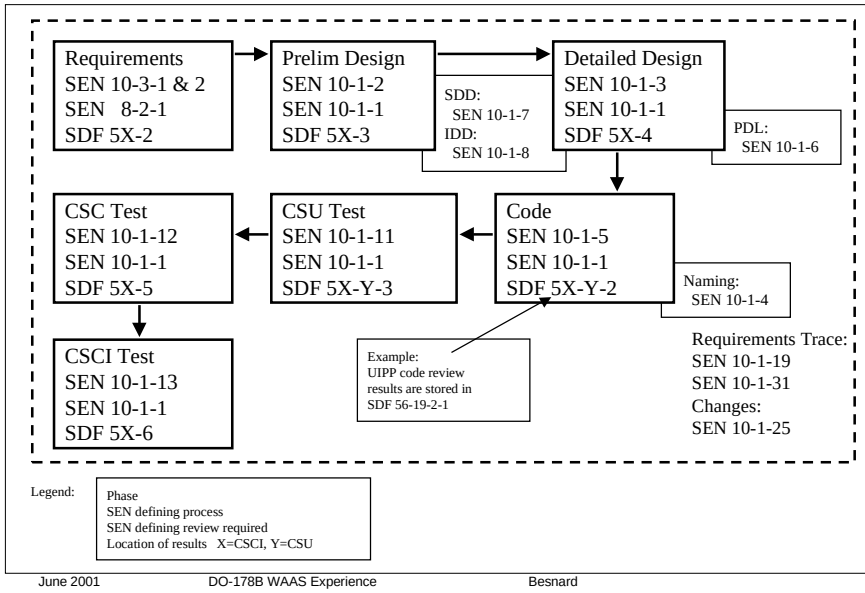
Our Approach to DO-178B

- Designated a DO-178B lead and focal point
- Bought several copies of DO-178B
  - Distributed them to safety engineers, test engineers, and all technical leads
- Generated a DO-178B compliant Software Development Plan (SDP)
- Made the PSAC an appendix to the SDP
- Modified internal work instructions to include DO-178B requirements

Our Approach (continued)

- Modified peer review checklists
  - Annotated with section numbers from DO-178B and our Common Software Process (CSWP)
- Achieved FAA audit “buy-in” on the process descriptions
- Created and maintained a compliance matrix
- Incorporated software safety personnel into the software development process
- Our software process improvement team focused on DO-178B compliance
- We hired an airborne DER as a consultant

Our process



Example from the Coding SEN

```
   #define LIMIT (5)
   ...
DO:
   if (LIMIT = = variable)

DON'T:
   if (Variable = = LIMIT)
```

```
DO:
      if (a != b)
      {
         temp = b;
      }

DON'T:
      if (a != b) temp = b;
OR
      if (a != b)
      temp = b;
```

FAA National Software Conference, June 2001
WAAS Experience

The compliance matrix

Objective Reference Number and Text	Where Satisfied	FAA Notes	Satisfied? Yes/No
A01-01 Software development and integral process activities are defined DO-178B Paragraph Number and Text 04.1a The activities of the software development processes and integral processes of the software life cycle that will address the system requirements and software level(s) are defined (subsection 4.2).	Life cycle process: SDP (CDRL A017-001B) SEN 10-3-1 SRS Standard SEN 10-3-2 SRS Develop. SEN 5-2-5 Safety marking	Incorporate clearer definition of IV&Y into SDP. Revise SRS standards and review to be more cohesive. Raytheon Comments: SDP updated SRS Standard (SEN 10-3-1) revised and approved by FAA	Yes Audit Date: 11/22/96 For audit? No Audit Note Numbers:
A01-01 Software development and integral process activities are defined DO-178B Paragraph Number and Text 04.3 Software Plans The purpose of the software plans is to define the means of satisfying the objectives of this document. They specify the organizations that will perform those activities. The software plans are:	The PSAC is included in the SDP as Appendix A. The SDP is CDRL A017. The CMP is CDRL A039. The QCPP is CDRL A030.	The criteria for transitioning between the different processes or when a process or partial process can be kicked off is not specified. . . SENs 10-1-3, 10-1-2 and 10-1-11 are OK. Need to review CSC and CSCI SENs Raytheon Comments:	Yes Audit Date: 6/12/97 For audit? No Audit Note Numbers:

June 2001 DO-178B WAAS Experience Besnard 19

Scorecard to date

Objective Number from DO-178B Annex A Tables

	1	2	3	4	5	6	7	8	9	10	11	12	13
Planning	X	X	X	X	X	X	X						
A-1	X	X	X	X	X	X	X						
Development	X	X	X	X	X	X	X						
A-2	X	X	X	X	X	X	X						
V&V Requirements	X	X	X	X	X	X	X						
A-3	X	X	X	X	X	X	X						
V&V Design	X	X	X	X	X	X	X						
A-4	X	X	X	X	X	X	X						
V&V Coding/Integration	X	X	X	X	X	X	X						
A-5	X	X	X	X	X	X	X						
Testing Integration	X	X		X		X							
A-6	X	X	X	X	X	X	X						
V&V of V&V		X		X		X							
A-7	X	X	X	X	X	X	X						
SW CM	X	X	X	X	X	X	X						
A-8	X	X	X	X	X	X	X						
SW QA			X	X									
A-9			X	X									
Certification Liaison	X	X	X	X									
A-10	X	X	X	X									

Objective status legend	
Objective Satisfied	X
Objective To Be Evaluated	
Objective not done, but no problems expected	
Objective not done, unresolved issues	
Serious issues; successful completion in doubt. Requires management visibility	

All open objectives Fall in this category.

CSCI legend	
C&V	GP
DCP	O&M

June 2001 DO-178B WAAS Experience Besnard 20